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PATENT SPECIFICATION

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COMPLETE SPECIFICATION

Improvements in Packing for Gas or Vapour and Liquid Contacting Apparatus

I, FRANCIS LEOPOLD MELVILL, a British Subject and a National of the Union of South Africa, residing at 84, Kerk Street, Johannesburg, Transaal, Union of South Africa, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention relates to packing for gas or vapour and liquid contacting apparatus. Although the invention has a wide range of utility, it is particularly useful in connection with contacting apparatus employed for the absorption, cooling, drying, cleansing or humidifying of gases, for the evaporation, cooling or heating of liquids, or for reaction purposes. Such apparatus say, for example, take the form of fractionating towers, scrubbers, cooling towers and the like. In such apparatus, a packing is usually employed for effecting intimate contact between the descending liquid and the ascending gas or vapour. As used herein the term "gas" includes vapour within its scope.

The invention provides a novel packing for gas and liquid contacting apparatus which avoids the presence of unequal gas or liquid pasages and prevents chanelling or segregation of the flowing gas in open spaces and of the liquid along surface areas, with the result that at any cross section of the packing at right angles to the general direction of countercurrent flow of the liquid and gas, the composition of the liquid and gas is substantially uniform.

The invention also provides a new and improved packing of the general character described, which feeds and spreads out the liquid evenly in a thin film and in a regular predetermined symmetrical manner as it descends in a treating chamber, so that even distribution of the liquid throughout the flow area of the chamber is afforded, which provides the maximum of effective (i.e. wetted) surface area per unit of packing space, offers a minimum of resistance to the passage of the ascending gas, and affords a maximum of intimacy of contact and interaction between liquid and gas, so that equilibrium between the fluid in either phase immediately adjacent to the inter-face and the main bulk of the fluid comprising the phase is rapidly attained.

The invention further provides a packing of the general character described, which comprises a series of simple, comparatively inexpensive elements requiring little or no shaping, and which can easily and expeditiously assembled.

Packing embodying the invention comprises a series of flat vertical sheets arranged in face to face contact, each of the sheets being formed of one integral piece and being provided with a lattice of mesh openings regularly and symmetrically arranged and separated by elements which extend obliquely and are integrally joined at predetermined intervals to form liquid mixing zones at the intervals. Adjoining elements of a pair converge downwardly at equal inclinations towards an integral juncture forming a liquid mixing zone, and diverge downwardly away from the juncture at equal inclinations and towards an integral juncture with other adjacent elements. The liquid is thereby directed downwardly along the sheet elements in the form of streams which encompass said elements, so that comparativly large surface stream areas are exposed in relation to the cross sectional areas of the streams. These thin streams flowing downwardly along a pair of adjoining downwardly converging elements meet at their juncture where they are thoroughly intermixed. The resulting mixture is subdivided and redistributed are thoroughly intermixed. The resulting diverging downwardly from this juncture.

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Since each of the pair of diverging elements converges downwardly towards a juncture with another adjoining element, the streams flowing along the diverging elements are intermixed with other streams, and then are evenly subdivided and re-distributed. This operation is repeated to the desired extent, so that uniform distribution of the liquid throughout the entire flow area of the packing sheet is effected. The sheets are vertically disposed in face to face contact, and are symmetrically arranged with respect to each other, so that the liquid is not only uniformly divided and distributed throughout each sheet, but is uniformly distributed laterally from sheet to sheet. Uniform distribution of the material throughout the entire flow area of the packing is thereby assured.

In the accompanying drawings:

Fig. 1 is a fragmentary axial vertical section, somewhat diagrammatic, of a gas and liquid contacting device containing a packing embodying the invention:

Fig. 2 is a transverse section, somewhat diagrammatic, of the contacting device taken on the line 2—2 of Fig. 1;

Fig. 3 is a fragmentary perspective of a perforated sheet forming part of the packing embodying the invention:

Fig. 4 is a front elevation of a portion of the packing.

Fig. 5 is a section taken on line 5—5 of Fig. 4: and

Fig. 6 is a section taken on line 6—6 of Fig. 4.

Referring to Figs. 1 and 2 of the drawing, the liquid and gas contacting device comprises a vertical cylindrical column or tower 10 containing the packing 11 of the invention. The gas to be contacted is delivered to the lower portion of the tower 10 below the packing 11, and flows upwardly through the packing, while liquid is fed to the upper portion of the tower above the packing, and flows downwardly through the packing and in intimate contact with the ascending gas in a manner to be described. The liquid is desirably delivered to the upper portion of the tower 10 and over the packing 11 in such scattered form as to be spread substantially evenly over the top of the packing 11, so that the liquid is distributed substantially uniformly throughout the packing a its upper end. For that purpose, the liquid may be delivered over the packing 11 in spray form, or may be delivered by a liquid feed device similar to that shown and described in my copending application Serial No. 607,284 (8203 filed 3rd April 1945) to feed the liquid in predetermined equally spaced thin streams over the packing.

The packing 11 is shown occupying the central portion of the tower 10, while the diametrically opposite side chordal sections 12 of the tower are left vacant or unpacked. A pair of partition plates 13 on the straight or chordal sides respectively of the packing 11, prevent flow into or out of the packing through those sides. The unpacked spaces 12 of the tower 10 may be sealed either at the bottom or the top in any manner well known in the art, to prevent by-pass flow through these spaces. The clearance between the arcuate peripheral portions of the packing 11 and the corresponding wall of the tower 10 may be sealed by any suitable means, as for example by means of layers 14 of glass wool.

The packing 11 comprises a series of flat vertical sheets 16 disposed in face to face contact, and regularly formed with a plurality of lozenge or diamond shaped openings 17. The sheet 16 preferably is made of metal or of plastic material which can be worked as required, and is formed in the manner of an expanded metal lath by providing in a sheet blank a series of regularly arranged, closely adjoining, parallel slits, set in parallel rows with the slits of adjoining rows staggered, preferably simultaneously expanding the blank to spread the slits into diamond-shaped openings 17, and rolling the sheets after cutting and expanding. The sections 18 of the sheet 16 which intervene between the slits and which enclose the expanded mesh openings 17, are in the form of slender elements, and extend obliquely at equal inclinations with the vertical. These elements 18 are identical in cross-sectional size, length, shape and finish, and their surfaces are of such material as to be substantially wetted by the liquid under normal operating conditions. The opposite faces of the sheets 16 are flat, so that effective face contact between the elements of adjoining sheets is assured which is not the case with packing formed of ordinary expanded metal sheets.

As shown, the lozenge or diamond shaped openings 17 preferably are all identical in size and shape, and are desirably, although not necessarily, in the form of equilateral parallelograms or rhombuses, with the acute vertex angles of each rhombus preferably, but not necessarily, in vertical alignment. The mesh openings 17 in each sheet 16 are arranged in vertical rows with the mesh openings of alternate rows medially displaced with respect to the mesh openings of intervening rows. As a result of this staggered arrangement, the elements 18 bordering the mesh openings 17 are disposed so that they converge downwardly

at equal inclinations in pairs towards a juncture 20 constituting the vertex of a mesh opening 17, and diverge downwardly in pairs from this juncture at equal inclinations, so that the thin liquid streams flowing along these elements will have the same flow and dimensional characteristics. These junctures 20 where adjoining elements 18 are integrally interconnected preferably are identical, and define liquid mixing zones serving the purpose to be disclosed.

The construction of a sheet 16 as described, lends symmetry to the arrangement of its constituent elements 18, provides a continuous solid path over which the liquid delivered to the top of the packing can flow downwardly thereover in thin streams, affords effective means of contacting the gas passing through the packing with the liquid exposed as a series of thin streams, and assures the turbulence necessary to secure mixing of the gases as will be more fully described.

The sheets 16 are substantially identical, except for widths, and are arranged vertically in face to face contact to form the composite packing 11. The sheets 16 desirably are relatively displaced vertically, so that the mesh openings 17 of one sheet are out of horizontal registry with the mesh openings of adjoining sheets. In the specific form shown, the mesh openings 17 of alternate sheets 16 are in horizontal registry, and the mesh openings of intervening sheets are also in horizontal registry but are medially staggered with respect to the mesh openings of the alternate sheets. In this honeycomb arrangement, the junction zones 20 in one sheet 16 will be centrally disposed with respect to the mesh openings 17 of adjoining sheets, so that each of the mesh openings 17 in one sheet will be divided by the adjoining sheets into four equal rhombus spaces 22 through which the gas passes in its general upward flow through the tower. The horizontally opposed elements of adjoining sheets 16 will contact each other at the mid-points 24 of these elements to form additional liquid mixing zones at these points. Adjoining packing elements 18 will extend at equal inclinations towards and away from these intersection zones 24.

With the arrangement disclosed, a portion of a stream flowing from a liquid mixing zone 20 along an element 18 in one sheet 16 merges at an intersection zone 24 with a similar portion of the stream flowing from another liquid mixing zone 20 along an element 18 of an adjoining sheet. In this manner, the liquid in one sheet 16 is not only distributed and mixed substantially uniformly throughout the width of the sheet, but is also distributed and mixed with the liquid of adjoining sheets. Substantially uniform distribution and mixing of the liquid throughout the entire horizontal flow section of the packing 11 is thereby assured. The interstices or spaces 17 defined by the adjoining sheets 16, are large enough to prevent capillary filming of the downwardly flowing liquid across these spaces, but preferably are as small as possible consistent with the liquid and gas load and the pressure drop required.

The sheets 16 desirably are sufficiently thick so that the spaces between horizontally aligned elements 18 of alternate sheets are not spanned by the capillary filming of the liquid. To achieve this result, the thickness of the sheets 16 will vary according to the character of the liquid being treated. In a specific application, the sheets 16 may be about one-tenth of an inch in thickness, and the width of the mesh openings 17 may be about four times this thickness. The sheets 16 can be held against relative vertical displacement by spot welding them together at their intersections 24, or if desired, other holding means may be employed for the purpose.

If desired, the composite packing 11 may be made of separate vertical sheets 16 relatively displaced vertically. Some of these sheets may be vibrated edgewise with respect to others to promote turbulences in the fluid flow or to prevent clogging of the packing where, for example, the liquid carries solids in suspension.

The sheets 16 arranged in face to face contact to form the composite packing, are set snugly between the two partition plates 13, so that the outside sheets fit snugly against these partition plates, and thereby effectively serve to dam the liquid flowing downwardly along these plates. The liquid is thereby returned by this damming action to mixing points in the packing from which it will be substantially uniformly distributed throughout the packing. The function of the outside packing sheets 16 in contact with the partition walls 13 is particularly important, since the countercurrent fluid tends to segregate or collect on the enclosing walls, thus upsetting their uniform distribution.

In the use of the packing of the invention, the liquid with which it is desired to contact the ascending gases is delivered to the top section of the packing as described, and is divided into a number of predetermined exposed thin streams which flow obliquely downwardly along the elements 18 in a direction generally counter to the direction of the flow of the gas. The maximum of liquid surface is thereby ex-

posed to the action of the ascending gas. The liquid stream flowing downwardly along a single oblique element 18 in one sheet 16, merges at a junction zone 20 with the liquid stream flowing down an adjoining oblique element 18 of the sheet. At this junction zone 20, the two streams are thoroughly intermixed, and the resulting mixture is then subdivided and redistributed equally between the elements 18 diverging downwardly from the junction zone in a sheet 16. Each of these diverging elements 18 in the sheet, constitutes part of another pair of elements 18 converging towards another junction zone 20, so that the two diverging distributed streams merge and intermix with other adjoining streams in the sheet, and then again become subdivided. This process is repeated, so that substantially uniform mixing and distribution of the liquid throughout the width of each sheet 16 is assured. Also, a portion of each liquid stream flowing along an oblique element 18 merges at an intersection zone 24 with a similar portion of the stream flowing along an oblique element 18 of an adjoining sheet 16, and the mixed liquid is then equally subdivided between those parts of the elements diverging downwardly from said intersection zone. The liquid in one sheet 16 thereby is not only distributed and mixed substantially uniformly throughout the width of the sheet, but also is distributed and intermixed substantially uniformly with the liquid of adjoining sheets.

If the flow along the different oblique elements 18 is not equal, the degree of irregularity will tend to become progressively reduced, due to the fact that each section will divide the whole of the liquid reaching a given mixing zone 20 or 24 equally with its element partner in that zone. This is particularly important in the upper section of the packing where the liquid feed may not be deposited uniformly over the top of the packing. By the equalizing process described, the distribution of the liquid under these conditions will become uniform in the upper section of the packing, and when once attained near the top of the packing will persist to the bottom thereof. The gas passing upwardly generally counter-current to the liquid, is subjected to sufficient turbulence to insure thorough mixing, thus avoiding the loss of efficiency which results when gas at the liquid and gas interface is not mixed as rapidly as possible with the main bulk of the gas, and when other purely local conditions within the packing tend to vary the composition of the gas across any section of the tower 10.

As a result of the construction of the packing of the invention, the velocity of the gas upwardly will be substantially the same at any point in any plane at right angles to the general direction of flow. Maximum intimacy of contact and maximum interaction between liquid and gas is obtained, and equilibrium is rapidly established between the material in either vapour or liquid phase immediately adjacent to the interface and the main bulk of the material comprising the phase. On any cross section of the packing at right angles to the general direction of flow of the liquid and the gas, the composition of the gas is substantially the same and the composition of the liquid in its constituent streams is substantially the same. The pressure drop of the liquid passing through the packing and the amount of liquid retained by the packing under normal operating conditions is comparatively low. A comparatively long path of travel of the liquid passing through the packing is provided so that retention of the liquid for a period long enough to assure the necessary saturation or interaction when the gas is assured. The length of the path of travel will vary, of course, with the slope of the elements 18.

Although for some purposes, the sheets 16 preferably are made of metal, as far as certain aspects of the invention are concerned, these may be made of any other material, and may be moulded into the desired shape. These sheets 16 may, for example, be made of suitable plastics.

The packing herein described is applicable to liquid and gas contacting devices, such as bubble towers, scrubbers, cooling towers, fractionating towers and the like, but it is not intended that the packing should be limited to equipment of this type. It is contemplated that the packing itself may be used as a catalyst. Under these conditions, the packing may, for example, be made of nickel, copper or any of the solid materials having the required catalytic properties. For that purpose, the catalytic packing may serve to increase the rate of reaction by contact with gas or mixtures thereof, or by contact with liquid or mixtures or emulsions thereof, or by simultaneous contact with liquid and gas, or mixtures thereof. The packing also may serve as a catalyst carrier, the catalyst, for example, being formed into beads which are threaded on the elements defining the packing. Further, if desired, the surface of the packing elements may be subjected to treatment to form a layer of catalytic material thereon. Moreover, the packing may serve as a carrier of a catalyst which takes the form of a liquid, and particularly a high viscous liquid such as phosphoric

acid with which it is desired to contact a gas or a mixture of gases.

If desired, the sheets 16 may be placed with the acute angles of the mesh openings in substantial horizontal alignment instead of in vertical alignment, as illustrated.

Inasmuch as certain elements of the packing extend in a downwardly inclined direction from the inner wall of the tower 10, liquid which reaches the wall by way of some of the elements will flow away from the wall by way of those certain elements and thus will tend to retain the liquid in the packing and prevent short circuiting flow down the wall of the tower.

The velocity of the vapour flowing upwardly through the packing will cause or tend to cause the liquid on the vertically inclined portions of the elements to assume a streamlined or tear drop shape such as would present the minimum resistance to the flow of vapours and this, together with the surface effects which become pronounced with thin films of liquid, will have the effect of distributing the liquid over the surface of the element with a tendency for a major part of the liquid to flow down the upper part of the element, the amount of liquid so flowing increasing with increased vapour velocity. The effect of this is to insure the maximum exposure of the liquid to the vapour and to facilitate the mixing of the streams of liquid at the juncture points.

Having now particularly described and ascertained the nature of my said invention and in what manner the same is to be performed, I declare that what I claim is:—

1. A packing for a gas and liquid contact device comprising a series of flat vertical sheets arranged in face to face contact, each of the sheets being formed of one integral piece and being provided with lozenge or diamond shaped openings regularly and symmetrically arranged, the elements of the sheet enclosing the mesh openings extending obliquely, and being integraly joined at predetermined regular intervals to form liquid mixing zones at the intervals.

2. A packing according to claim 1 in which the elements of each sheet enclosing the mesh openings are of the same length and cross section.

3. A packing according to claim 1 in which each of the sheets is provided with a lattice of rhombus mesh openings symmetrically arranged with opposed vertices of each opening in substantial vertical alignment.

4. A packing according to claim 3 in which the sheet openings are arranged in vertical rows with the openings of alternate rows medially staggered with respect to the openings of intervening rows.

5. A packing according to claim 1 in which the sheets are regularly staggered, whereby the mesh openings in one sheet are regularly subdivided into spaces of smaller diamensions by the elements of adjoining sheets.

6. A packing according to claim 1 in which the sheets are made of flattened expanded metal.

7. A gas and liquid contact device for vertical counter current flow comprising a tower, and a packing in the tower including a series of similar flat vertical sheets arranged in face to face contact, each of the sheets being formed of one integral piece and being provided with a lattice of similar mesh openings regularly and symmetrically arranged, the elements of the sheets enclosing the mesh openings being similar in shape and dimensions and extending obliquely at equal inclinations, the elements being integrally joined at predetermined regular intervals to form liquid mixing zones at the intervals, substantially as exemplified in the accompanying drawings.

Dated this 29th day of March, 1945.
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